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ON GASTRIC SENSATION.

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Our knowledge concerning gastric sensitivity is derived from a small number of researches, partly experimental and partly clinical.

The experiments on animals have consisted in applying some form of stimulation to the stomach and then observing the various reactions induced by this means. The action of local emetics ($CuSO_4$ and tartar emetic) was studied by Openchowski[1], who found that the afferent paths for exciting vomiting in this manner are contained in the vagi.

The sensory innervation of the peritoneal surfaces of the stomach was studied by Ducceschi[2], who tested the effect of electrical and mechanical stimulation on the respirations and general reactions of the animals. His results led him to infer that, whilst sensory stimuli are conducted from the entire outer surface of the stomach by both the vagi and the splanchnics, those passing by the vagi are alone capable of exciting vomiting.

Head[3] noted that the areas of cutaneous tenderness accompanying gastric disorders correspond with the distribution of the 7th, 8th and 9th dorsal nerves, but the work of Ducceschi has as yet alone yielded experimental evidence regarding the importance of the spinal nerves in the sensory innervation of the stomach.

Hertz, Cook, and Schlesinger[4], in a recent study in man, observed that the lower end of the œsophagus was considerably more sensitive than the mucous membrane of the stomach. In investigating the sensitivity of the gastric mucosa it is, therefore, essential to confine the action of the emetic substances strictly to this surface. Whether or not

[1] *Arch. f.* (*Anat. u.*) *Physiol.* p. 554. 1889.
[2] *Arch. di Fisiol.* p. 521. 1904—5.
[3] *Brain*, xvi. p. 66. 1893.
[4] This *Journal*, xxxvii. p. 481. 1908.

any precautions of this kind were taken by Openchowski in the research already mentioned it is impossible to state, for no actual experimental details are furnished and only an epitomised account is given of his results.

The present research was, therefore, undertaken at the suggestion of Professor Brodie with the idea of making a more extensive study of gastric sensation and especially of the paths taken by sensory impulses from the mucous surface of the stomach.

In selecting a form of stimulation for the gastric mucosa, the faradic current appeared the most desirable. I found, however, that neither the bipolar nor the unipolar method of stimulation, when applied to the mucous surface, was capable of inducing vomiting and, after testing a number of local emetics, I finally resorted to warm mustard solution as yielding the most satisfactory results.

The method of procedure in the experiments with mustard was as follows: the animal (cat) was anæsthetised with A.C.E. mixture and ether. The abdomen was opened in the middle line, and the stomach drawn out and protected by cloths wrung out of warm saline solution. The dorsal and ventral branches of the vagus were then isolated on the œsophagus just below the diaphragm and a ligature tied tightly around the œsophagus underneath the nerves. The pylorus was also firmly ligatured. An opening was made in the ventral surface of the fundus and a glass tube tied in. The other end of the tube was connected by a piece of rubber tubing with a small funnel. The stomach was emptied and thoroughly washed out. The mustard solution was then introduced. Almost immediately the respirations were increased in rate and force and tongue and swallowing movements, accompanied by salivation, were induced, whilst after an interval of 1—3 minutes, typical vomiting movements ensued. This result may be obtained several times in succession, the stomach being washed out after each experiment.

It will be seen that under these experimental conditions no actual discharge of the stomach contents is possible, and the occurrence of the vomiting reflex is indicated merely by the characteristic contractions of the diaphragm and abdominal muscles. The term vomiting will, accordingly, be employed in this special sense in the remainder of this paper.

In order to determine the afferent paths involved in this vomiting reflex the experiment was carried out as already detailed but, in addition, the splanchnics were isolated on both sides. Vomiting was

then excited by mustard. The splanchnics were next divided and it was found that vomiting could still be induced. The vagi were then divided on the œsophagus and it was observed that reflex vomiting was now no longer possible. This has been confirmed in several experiments.

In other similar experiments it was found impossible to induce vomiting after division of the vagi, the splanchnics alone remaining intact. We may, therefore, conclude that the vagi alone conduct from the gastric mucosa the impulses which are capable of exciting vomiting.

For the purpose of securing tracings of the vomiting movements, the operation on the stomach was performed on a cat anæsthetised with urethane. The respirations were recorded by causing the animal to breathe into a large bottle connected with a tambour. In Fig. 1 is shown the result of introducing a 5 p.c. solution of mustard into the stomach.

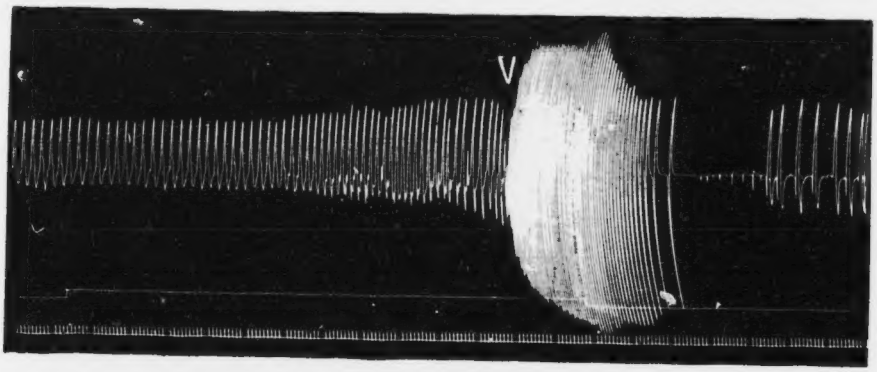

Fig. 1. Record of respirations in cat. Vomiting movements begin at *V*. Signal shows introduction and removal of mustard. Time in seconds.

The respirations are seen to become considerably quicker and deeper and vomiting occurs in 1 min. 54 secs. The vomiting movements take place with greater frequency than the preceding respirations, but become considerably slower after the removal of the mustard from the stomach. Following the vomiting there is a brief interval of rest, after which the breathing is gradually resumed.

It is known that stimulation of the trunk of the vagus may cause vomiting, but the effect of stimulating the branches to the stomach does not appear to have been investigated. On trial it was found that excitation of both the dorsal and ventral branch was effective.

In Fig. 2 is shown the result of exciting the central end of the dorsal vagus with the faradic current. The respirations, which were recorded in the usual manner, become deeper during the stimulation, and some imperfect attempts at vomiting occur, but complete vomiting does not take place until after the excitation. Powerful vomiting sometimes, however, appears during the actual course of the stimulation. The respiratory excursions are considerably more extensive after, than before, the period of vomiting.

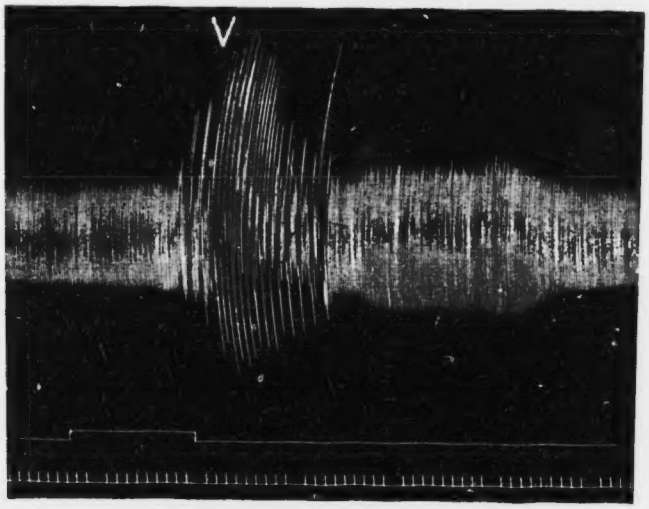

Fig. 2. Effect of stimulating dorsal vagus. Vomiting occurs at *V*. Distance of secondary 10 cm. Time in seconds.

Frequently the nerves must be subjected to several excitations before vomiting is elicited, and in these cases a deepening of the respirations is often the only visible evidence of the stimulation. This is seen in Fig. 3, from a later part of the same experiment shown in Fig. 2, after the irritability of the nerves has become somewhat reduced. In other cases a few vomiting movements take place as a result of the first stimulation, whilst a succeeding brief excitation suffices to provoke powerful vomiting.

It was next necessary to ascertain by which vagus trunk in the neck the impulses travel respectively from the dorsal and ventral vagal branches at the lower end of the œsophagus.

In order to determine this point e... branch of the vagus was stimulated, whilst the vagi in the neck were successively cooled. The effect of these procedures on the vomiting reflex was meantime noted. The results indicate that, whilst in some cases the excitation passes from the dorsal branch exclusively up the right vagus, and from the ventral branch up the left vagus, in many instances impulses from each stomach nerve are transmitted by both vagi.

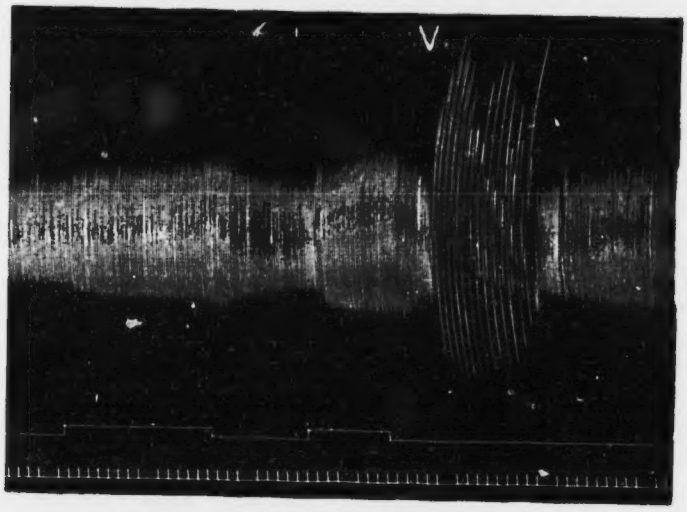

Fig. 3. Effect of stimulating dorsal vagus. Vomiting occurs at *V*. Distance of secondary 7 cm. Time in seconds.

The final point to be determined in tracing the further course of the impulses up the vagi was which of the rootlets belonging to the 9th, 10th and 11th cranial nerves convey the excitation to the medulla. The lower rootlets were first exposed and vomiting was induced by stimulating the central ends of the vagal branches to the stomach. The ascending rootlet of the 11th nerve was then divided on each side. Stimulation of the vagus nerves again excited vomiting. The impulses from the stomach causing vomiting are, therefore, not conveyed to the medulla by these rootlets.

As the exposure of the upper rootlets involved the removal of a portion of the cerebellum considerable shock invariably resulted, and hence it was found impossible to excite vomiting by the action of

mustard. Excitation of the gastric nerves was, however, not infrequently effective. After section of the left vagus in the neck stimulation of the ventral branch of the vagus caused weak vomiting, whilst stimulation of the dorsal vagus caused more powerful vomiting. The upper rootlets on the right side were next divided and it was found that under these circumstances vomiting could no longer be excited by stimulating either gastric nerve. Although, in the experiments so far performed, the upper rootlets have been divided only on the right side, it is reasonable to suppose that the *a* group of rootlets transmits, on both sides, the afferent impulses which excite vomiting.

It was stated earlier that considerable salivation is invariably associated with the vomiting produced by the action of mustard in the stomach. As previous observers[1] have shown that stimulation of the vagus in the neck causes reflex salivary secretion, I excited the vagal branches to the stomach, and obtained a very definite flow of saliva in a cannula inserted in the submaxillary duct of an animal anæsthetised with chloroform and urethane.

The results so far described show the significance of the vagi as afferent gastric nerves, and I now undertook a number of experiments with the object of demonstrating, if possible, whether any similar sensory function might be attributed to the splanchnics.

With this object in view the œsophagus was divided just below the diaphragm in an animal (cat) anæsthetised with urethane and the pylorus was ligatured. A tube was tied into the opening in the cardia of the stomach and the respirations were recorded in the manner already described. Under these conditions all possible branches of the vagi to the stomach are divided, whilst most, if not all, of the sympathetic connections are retained. It was found, however, that neither the introduction of strong mustard solution nor of bromine water into the stomach caused any alteration in the respiratory movements.

In other similar experiments a cannula was tied in the submaxillary duct, but mustard solution and bromine water failed to excite any reflex flow of saliva.

I have thus been unable to prove that sensory impulses of any kind are conveyed by the splanchnics from the mucous surface of the stomach, and cannot, therefore, add any experimental confirmation to the conclusions of Head.

[1] Cp. Langley, *Schäfer's Text-Book of Physiology*, vol. i. p. 482. 1898.

SUMMARY.

1. Vomiting induced by the action of a local emetic like mustard is prevented by division of the vagi.

2. Stimulation of the central ends of the vagal branches to the stomach causes reflex flow of saliva and vomiting.

3. Experiments so far performed indicate that the excitation causing vomiting is conveyed to the medulla by the a group of rootlets.

4. I have been unable to demonstrate that the splanchnics transmit sensory impulses of any kind from the gastric mucosa.

It gives me pleasure to thank Professor Brodie for his very kind supervision of this work.